

Ns 2-362

N67-83402

(ACCESSION NUMBER)

(THRU)

FACILITY FORM 602

CP-83721

(PAGES)

(CODE)

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)



OBSERVATORY—ERECTED 1843

GEORGETOWN UNIVERSITY

Washington 7, D. C.

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**SEMI-ANNUAL STATUS REPORT NO. 7 ON SPECTROSCOPIC STUDY
OF SOLAR AND PLANETARY ATMOSPHERES**

FEBRUARY 1, 1966 to AUGUST 1, 1966

WORK DONE UNDER NASA GRANT

NSG - 362

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SEMI-ANNUAL STATUS REPORT NO. 7 TO THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

"SPECTROSCOPIC STUDY OF SOLAR AND PLANETARY ATMOSPHERES"

NAME AND ADDRESS OF INSTITUTION: GEORGETOWN UNIVERSITY
WASHINGTON, D. C. 20007

PROJECT DIRECTOR: Dr. Francis J. Heyden, S. J.

ASSISTANT SCIENTIFIC DIRECTOR: Dr. Carl C. Kiess

PROJECT HEAD: Dr. Whiting R. Willauer

Work Performed: This report is divided into two areas, the first area is observations of the planets, and the second is the simulation of the Martian atmosphere and analysis in the photographic region.

Area 1. Planetary Observations.

Venus was at inferior conjunction on January 26, 1966; at greatest brilliancy on March 1, 1966; and at greatest western elongation on April 6, 1966. Twelve plates were taken of Venus during this period.

Mars was at conjunction on April 29, 1966, and will be at opposition on April 15, 1967. No plates were taken of this planet during the period. However, preparations for the April 1967 conjunction are being made. These preparations include the test and evaluation of a new quartz spectrograph and a new high speed emulsion.

Jupiter was at opposition on December 18, 1965; stationary on February 15, 1966; and at conjunction on July 5, 1966. Ten plates were taken of Jupiter during this period.

Quartz Spectrograph.

A large quartz prism spectrograph of the Littrow type was obtained on an indefinite period loan from the National Bureau of Standards. The

spectrograph was manufactured by Adam Hilger, Ltd. The optical network consists of a small right angle prism, a quartz collimator lens, and two large prisms. These large prisms, a 60° cornu and a single 30° , were cut from the largest crystal of optical quartz ever available.

It is hoped that this spectrograph will be operational for the April 1967 opposition of Mars. It has the advantage of being very fast and giving high dispersion. It has the disadvantage of scattered light which is inherent in all Littrow spectrographs. It is planned to test the spectrograph using Jupiter which is at opposition on January 20, 1967, three months before the Martian opposition. If the tests are successful this spectrograph will be used in conjunction with a 50 foot focal length siderostat. If the tests are unsuccessful, then the Martian spectra will be obtained using grating spectrographs.

In this spectrograph the light passes through the slit and is then deviated through an angle of 90° and diverged to fill the quartz lens by means of a small right angle prism. The quartz lens acting as a collimator renders the light from each point of the slit parallel and delivers a beam that fully illuminates the 20cm. face of the 60° quartz prism. The rays are refracted by the 60° prism, traverse a short air gap, and then enter the 30° prism. The light traverses the 30° prism and is reflected by a silver amalgam on the back face. The light passes back through the prism train. In all, the light is dispersed four times before it is collected by the quartz lens, and brought to focus on a curved surface to which the photographic plate is attached. Different spectral regions can be obtained by rotating the prism train and the plate holder about a vertical axis.

The chief advantage of the Littrow style mounting is that a single lens serves as both the collimator and the camera lens. The rotational effect due to quartz is avoided by the use of a Cornu prism consisting of a 30° prism of right handed quartz and a 30° prism of left handed quartz, and the single lens - 30° coated prism combination.

As in all prismatic spectrographs, the instrument's dispersion is not constant. In the region from 2000 to 3000 Å, the dispersion varies from 0.25 Å/mm to 1 Å/mm; from 3000 to 4250, 1 Å/mm to 2.5 Å/mm. The Littrow's resolving power is approximately 0.75 m.

Area 2. Analysis of the Nitrogen Dioxide Spectra in the Visual Region.

As of yet it has not been definitely proved or disproved whether the oxides of nitrogen exist in the Martian atmosphere. In order to prove or disprove the existence of the oxides of nitrogen, it is necessary to positively identify spectral bands or lines in the planet's spectrum. The fall of the intensity of the Martian spectrum toward the ultraviolet, and the various phenomena such as yellow clouds lead to a suspicion of nitrogen dioxide. The positive identification of nitrogen dioxide is fraught with many difficulties.

1. The oxides of nitrogen and other suspected components of the Martian atmosphere exist in the earth's atmosphere. In order to reduce this ambiguity a comparison spectra must be obtained, preferably the moon's spectrum juxtaposed to the spectrum of Mars, and as near in time and altitude as the planet.

2. The spectrum of nitrogen dioxide is very complex and has not been analyzed in the visible region. The tables of laboratory spectra made by Miss Carwyle for her doctorate dissertation at the University of Virginia in 1927 do not correlate with the work of Corliss at the Bureau of Standards in 1961 (unpublished data) nor do they correlate with data obtained at Georgetown College Observatory. It is difficult to say how Miss Carwyle went astray, however, it would be desirable at some future date to perform this work again. In order to obviate this problem, the spectrum of pure nitrogen peroxide gas is compared to Martian absorption features. However, no attempt is planned in this present study to determine the energy levels leading to the transitions in the photographic region.

3. The photographic densities of the lines and bands of NO_2 are strongly effected by path length and exposure time.

a. It is rather difficult to change the path length of NO_2 without contaminating the gas. The gas which is obtained from a commercial outlet has a small amount of impurities. These impurities are first eliminated by partial distillation. Once the gas has been purged of impurities, the path length has to be determined. The path length is a function of pressure and temperature. The temperature can be measured by immersing the optical tube in a constant temperature bath. The pressure measurements are rather difficult. The main difficulty is that nitrogen peroxide is highly corrosive and will attack mercury or the solder and metal coating of thermal conductivity pressure gauges.

The problem was solved by attaching a glass freeze-out finger to the side of our optical cell. By changing the temperature of the solid dinitrogen tetroxide in the finger, the vapor pressure of the gas in contact with the solid can be regulated. Knowing the temperature, the total pressure of the nitrogen dioxide - dinitrogen tetroxide system can be calculated using the pressure-temperature formula of Giaque and Kemp. The results of these calculations can be compared to Egerton's vapor pressure tables. Then the partial pressure of the nitrogen dioxide can be calculated from Schreiber's formula.

b. Because of the photochemical properties of nitrogen dioxide the path length of a given sample will change when subjected to ultraviolet light. This is especially evident when the sun's light is passed through the optical tube. The sun's light tends to wash out many of the fine details in the spectra while still maintaining the ultraviolet fall-off. This mechanism may be operative on Mars acting as an ultraviolet shield similar to the ozone layer in the earth's atmosphere. If this is the case it might be a fortuitous phenomena which could protect the Martian surface from ultraviolet radiation.

In order to limit the amount of photodissociation in the laboratory sample a Corning Filter number 3385 was used to filter out the solar radiation below 4410 angstroms. This cut-off point is much higher than the cut-off imposed by ozone in the earth's atmosphere, and is probably higher than the ultraviolet cut-off point that exists on Mars.

By careful ordering of the sequence of exposures, we have been able to obtain spectra of the filtered and unfiltered sunlight plus nitrogen dioxide as well as black body plus nitrogen dioxide on a single plate.

The ultraviolet light tends to broaden the absorption features due to photochemical dissociation and this influences the entire visible spectra. This broadening tends to preserve the ultraviolet fall-off, but makes the identification of the spectra difficult. As a matter of fact it would be nearly impossible to identify a known laboratory sample once it has been exposed to ultraviolet radiation. Neither O'Leary (A Revised Upper Limit of Nitrogen Dioxide in the Martian Atmosphere; Ap.J. Vol. 77, pp. 168-177, 1965) nor Marshall (Improved Test for Nitrogen Dioxide on Mars; Lunar and Planetary Laboratory 2, 167, 1964) considered this photochemical broadening effect which would greatly influence their results in the 4000 to 5000 angstrom region.

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Financial Report.

C. f. University Nonprofit Institutional Management Report
(forwarded by the University Treasurer's Office).